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(51) INT CL^6
B60R 21/28

(52) UK CL (Edition O)
B7B BSB

(56) Documents Cited
EP 0568901 A2 **US 5388860 A** **US 5366242 A**
US 3861712 A **US 3788666 A**

(58) Field of Search
UK CL (Edition N) **B7B BSB**
INT CL^6 **B60R 21/08 21/16 21/28**

(54) Airbag vent valves opened by a command signal

(57) A valve in the wall of an airbag is opened in response to a time delayed or pressure based signal after the initiation of inflation. Embodiments include:

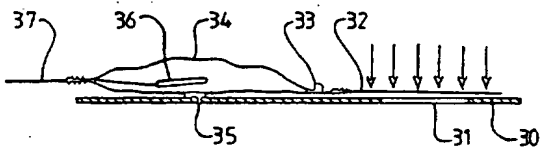
A plastics insert of defined thickness incorporating an arcuate area of reduced thickness which is punctured by a pyrotechnic and allowed to rip open under the gas pressure (Figs 2,3).

A frame supporting a pyrotechnic cylinder, the piston of which comprises a cruciform knife for puncturing the outer skin of the bag (Figs 4, 5).

The bag 30 has an aperture 31 over which a layer of fabric lies (Figs 6, 7), retained by a frangible stitching. One end of the layer is passed under a guide 33 and attached to the peripheral edge of an uninflated balloon 34. Inflation results in the fabric being pulled from across the mouth of the aperture.

Further embodiments include linearly (Fig 9) and angularly (Fig 12) movable shutter like 'hit and miss' valves driven by pyrotechnics where a set of apertures, initially miss-aligned are aligned to permit gas escape. There is also an iris like valve.

FIG 6



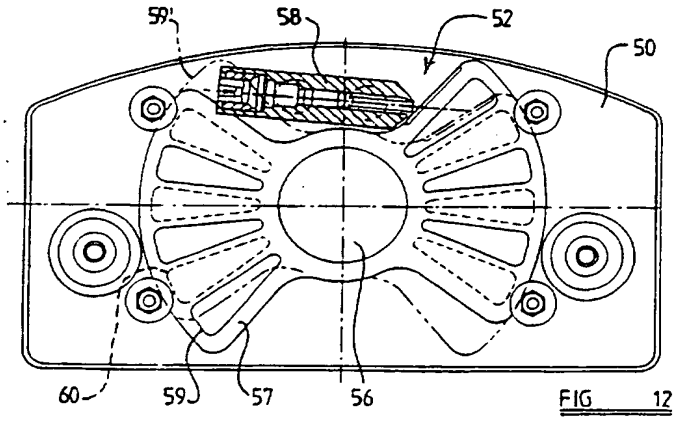


FIG 12

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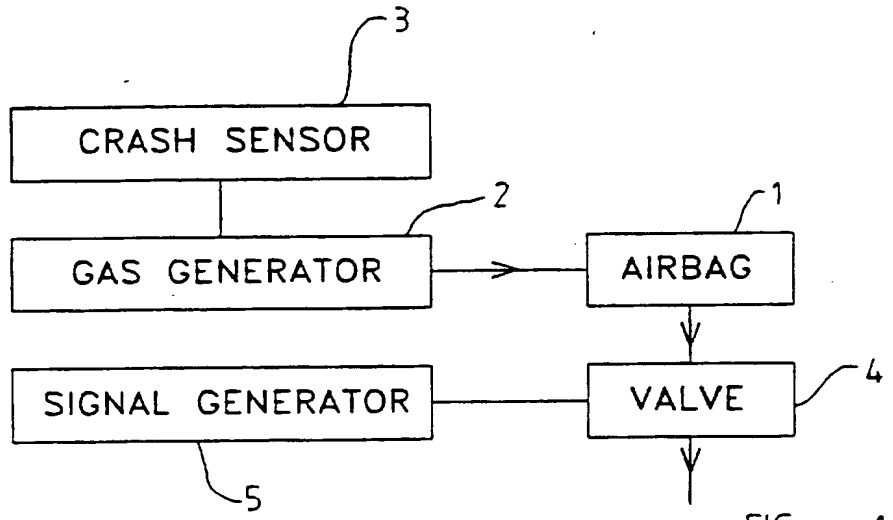


FIG 1

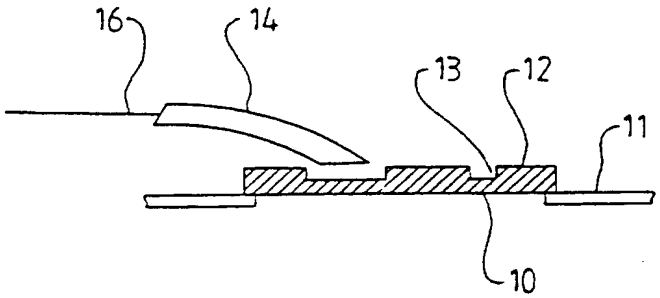


FIG 2

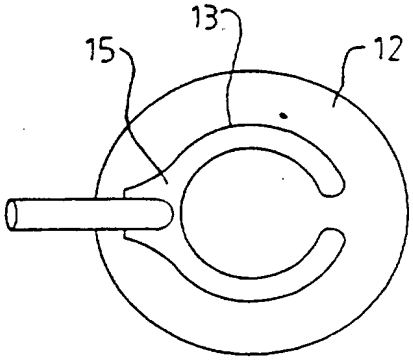
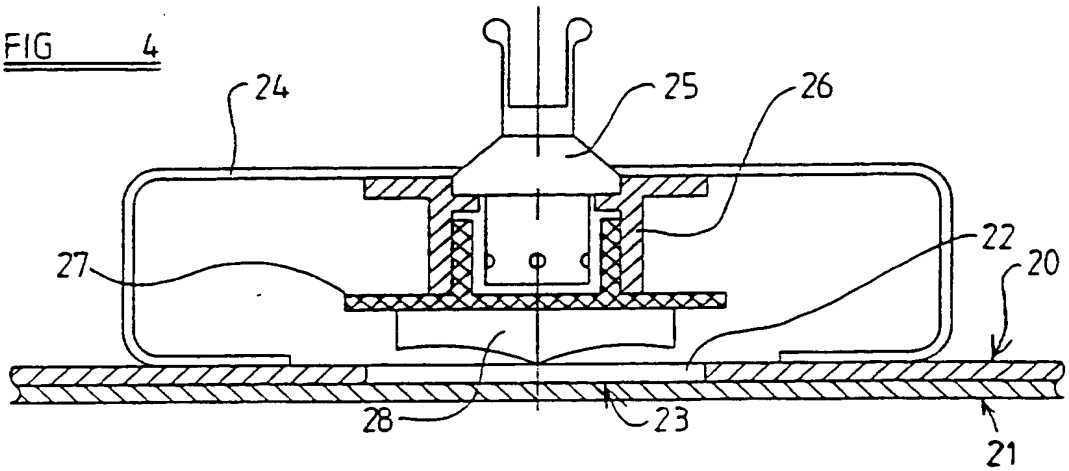


FIG 3

FIG 4



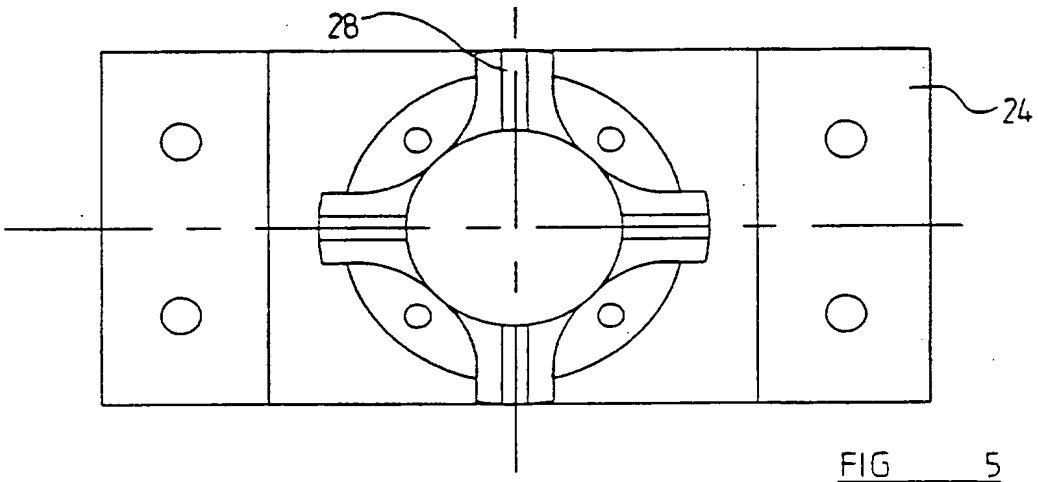


FIG 5

FIG 6

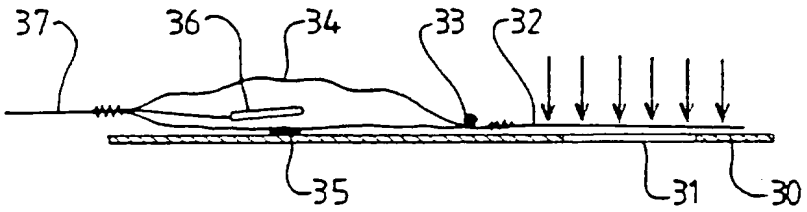
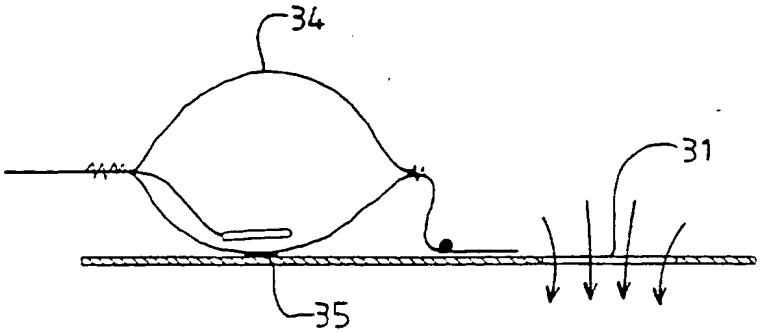


FIG 7



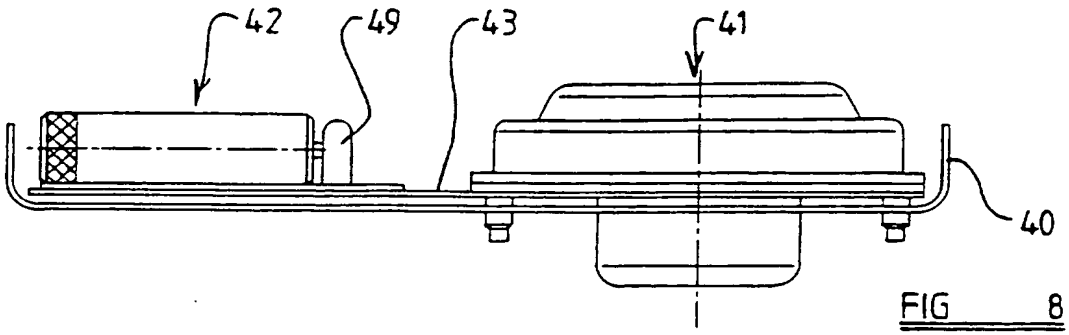


FIG 8

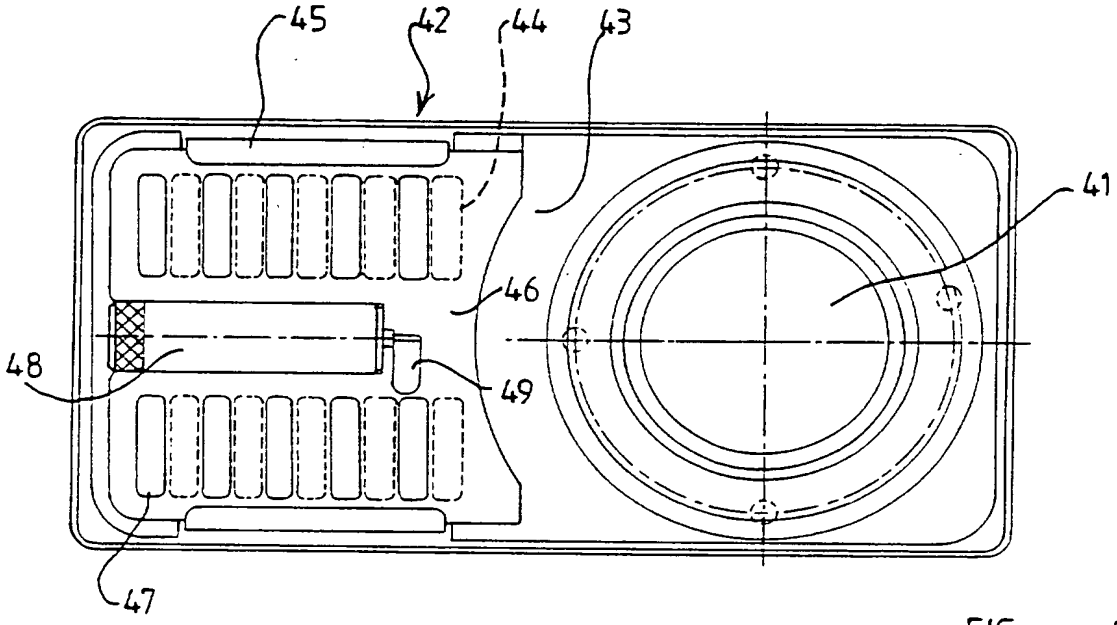


FIG 9

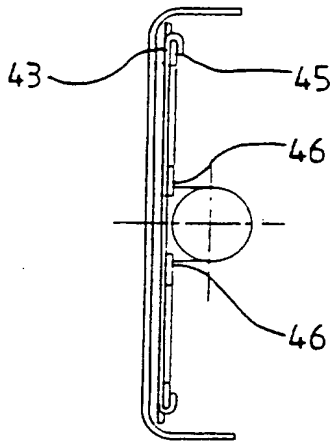


FIG 10

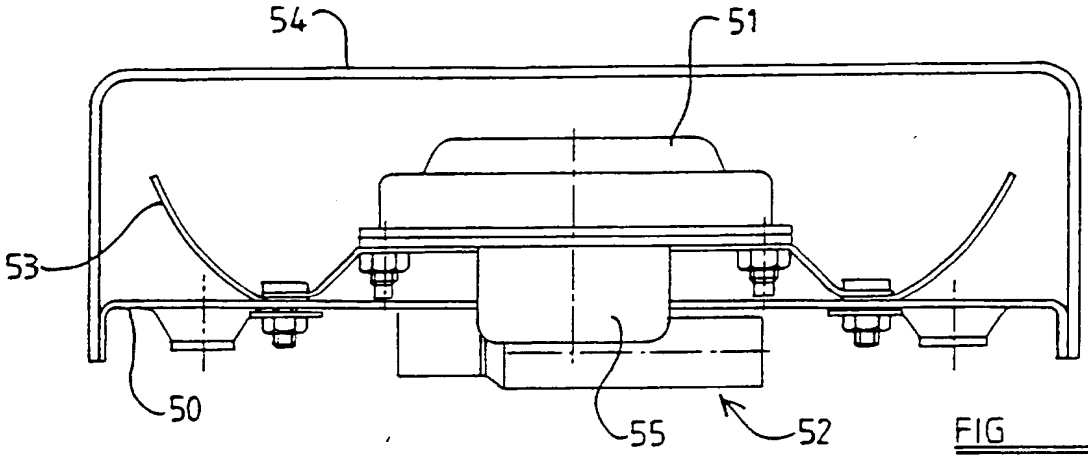


FIG 11

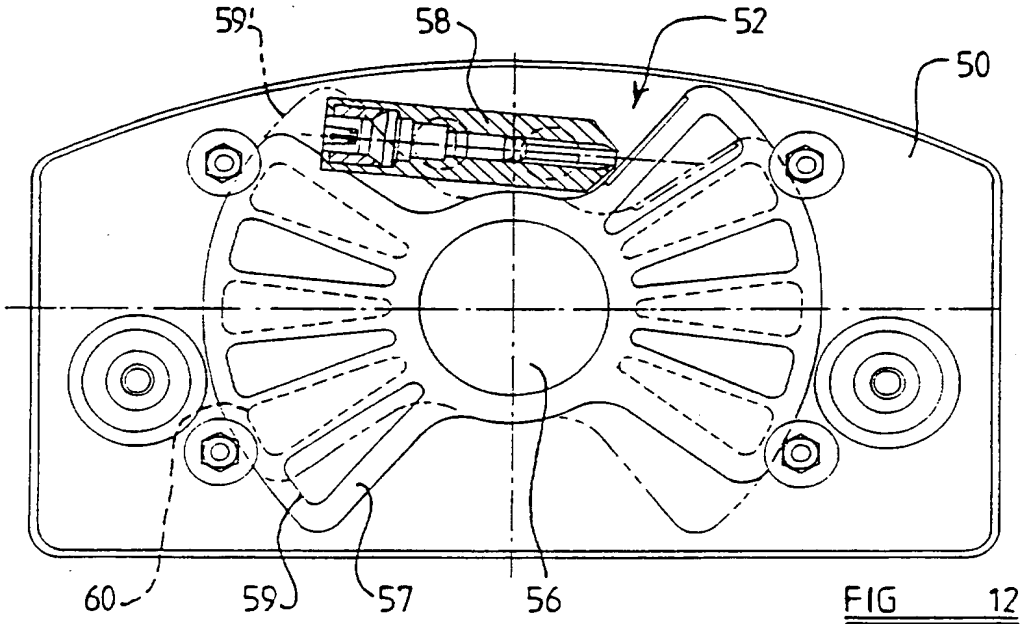


FIG 12

FIG 13

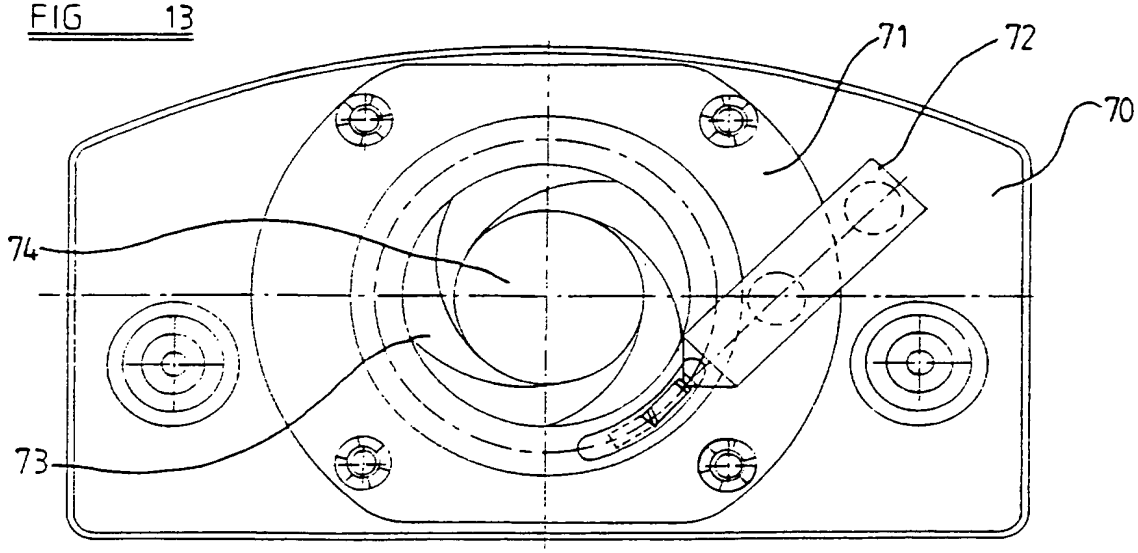


FIG 14

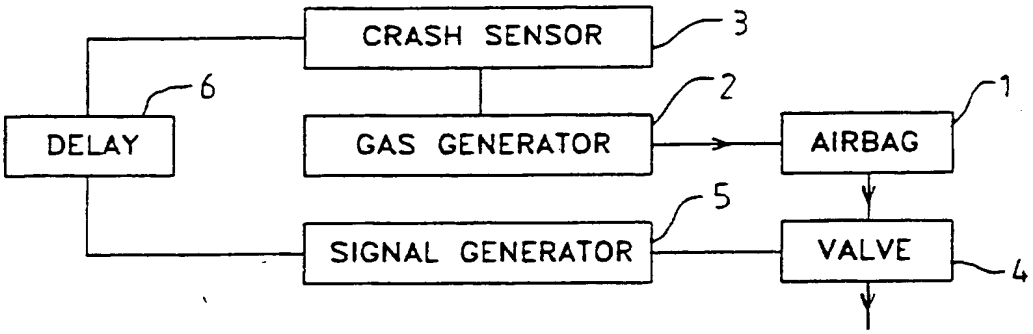
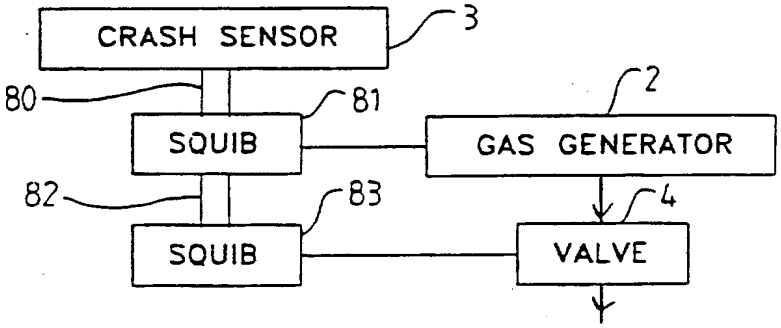


FIG 15



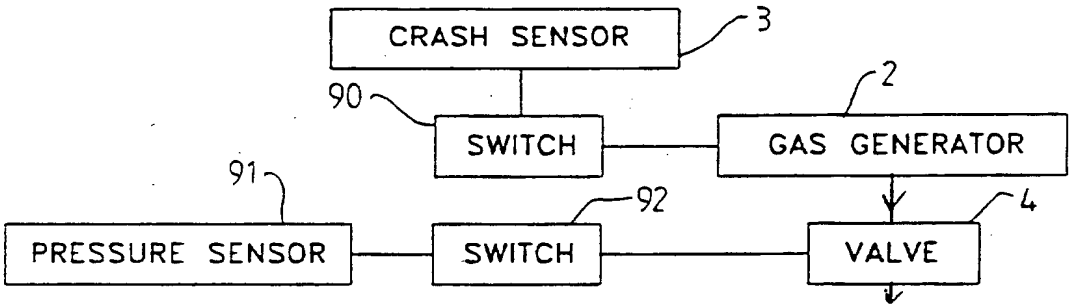


FIG 16

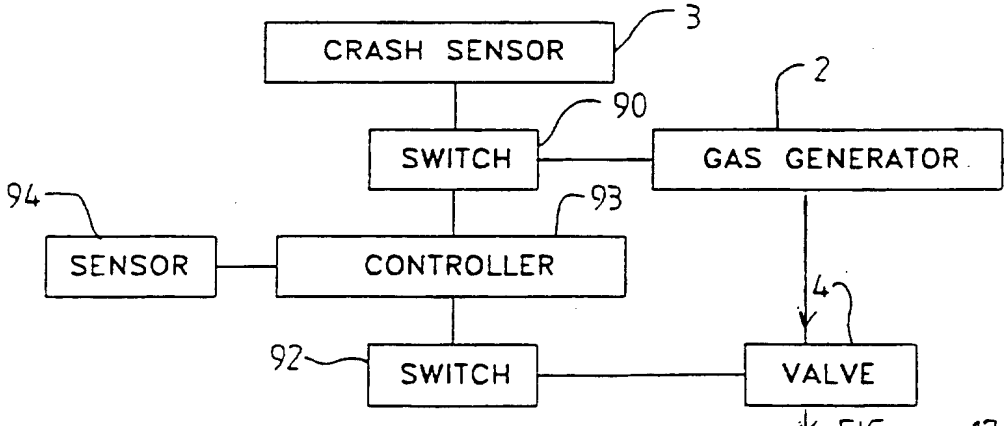


FIG 17

PATENTS ACT 1977

Agents' Ref: P10068GB-NHF/er

DESCRIPTION OF INVENTION

"IMPROVEMENTS IN OR RELATING TO AN AIR-BAG ARRANGEMENT"

THE PRESENT INVENTION relates to an air-bag arrangement and more particularly relates to an air-bag arrangement adapted to provide protection for the driver or other occupant of a motor vehicle.

Air-bags are provided in motor vehicles to provide protection for the driver or other occupant of the motor vehicle in the event that an accident should arise. The air-bag is inflated relatively swiftly when an accident has been detected, for example, by a deceleration or impact detector, the air-bag being located in front of the driver or occupant of the vehicle to provide a "cushion" which decelerates the driver or other occupant of the vehicle.

It is necessary for an air-bag to be inflated very swiftly if the air-bag is provide the desired degree of protection, the inflation time being measured in terms of a few one-hundredths of a second.

Gas has to be supplied to the air-bag at a substantial flow rate to inflate the bag. As a consequence when the bag is in the initial folded condition, the pressure present within certain parts of the bag as the bag is inflated may be very high. When the bag is fully inflated, the outer skin of the bag may be very "stiff" or "hard" due to the pressure of gas within the bag.

If the driver or occupant of the vehicle impacts with a bag where the interior pressure is very high, the bag may not provide the desired cushioning effect.

It has been proposed to provide an air-bag with a permanently-open venting opening. Gas can escape through the opening while the bag is being inflated and after inflation. However, the opening has to be small, since otherwise too much gas may escape from the air-bag before the driver or occupant of a vehicle impacts with the air-bag, meaning that the air-bag is then too soft to provide the desired cushioning effect.

DE-A-1,780.304 discloses arrangements in which a venting hole is provided which is initially sealed. The seal is intended to be broken to permit gas to escape through the venting opening when subjected to a high pressure within the bag caused by the impact of the driver or occupant of the vehicle with the exterior of the bag. It is to be understood that when the driver or occupant of the vehicle impacts with the exterior of the bag, the pressure on the interior of the bag will rise. Thus this prior art arrangement proposes that in response to the driver or occupant impacting with the bag, the venting opening will be un-sealed, permitting gas to escape. It is believed, however, that there is a severe risk that bags of this design may malfunction. As has been mentioned previously, the pressure within certain regions of an air-bag may reach very high values during initial inflation of the air-bag. Such regions of high pressure are found especially before the bag has left the housing in which it is stored, and before the bag has become unfolded. Should the region of the bag provided with the sealed aperture be exposed to such high pressure during the initial instants of inflation, the seal may be broken prematurely.

DE-A-3,618,060 discloses a further arrangement in which the air bag is provided with an initially sealed venting hole. The air-bag has a sealing disc stitched to it which initially seals the venting hole. A tab extending from the sealing disc is connected to another part of the exterior of the bag. The tab is connected to part of the exterior of the bag which is spaced from the venting hole by a distance greater than the length of the tab. Thus in the initial condition part of the fabric of the bag between the venting hole and the point where the tab is secured to the bag is tucked or folded. As the bag becomes fully inflated, the pressure within the bag tends to unfold the tucks or folds, causing the tab to tear the sealing disc away from the venting opening. The venting opening is thus opened as the bag becomes fully inflated. In certain circumstances this can be undesirable, since the bag may have deflated substantially before the passenger or occupant impacts with the bag.

The present invention seeks to provide an improved air-bag arrangement.

According to this invention there is provided a safety arrangement for a motor vehicle comprising an air-bag, gas generator means adapted to inflate the air-bag, crash sensor means adapted to activate the gas generator to inflate the air-bag, a valve which is initially in the closed condition, but which can be opened to permit gas within the air-bag to be vented from the air-bag, the valve being opened in response to a signal, means being provided to generate the signal to open the valve after the bag is at least partially inflated.

Preferably the valve is actuated by pyrotechnic means.

In one embodiment of the invention the said pyrotechnic means are adapted to burn part of the valve element to cause the valve element to open.

Alternatively, the valve element comprises an element of material of pre-determined thickness having a region of lesser thickness, the pyrotechnic charge being adapted to burn part of the region of lesser thickness.

In a further alternative embodiment of the invention the valve comprises a knife or cutting blade adapted to cut part of the air-bag. The knife may be mounted on a piston element which cooperates with a cylinder associated with the pyrotechnic charge, activation of the pyrotechnic charge being adapted to drive the knife from an initial position to a position in which the knife or cutting blade cuts the air-bag.

In an alternative arrangement the pyrotechnic device is contained within an inflatable balloon, the inflatable balloon being connected to an element which initially seals an aperture formed in the air-bag, the arrangement being such that inflation of the balloon causes the said element to move to a position in which the aperture in the air-bag is no longer sealed.

Conveniently the valve comprises two elements, one element being moveable relative to the other element, each of the elements defining at least one aperture therein, the arrangement being such that the aperture or apertures are initially mis-aligned but, subsequent to the said movement, are co-aligned. One element may be slidable linearly relative to the other element, but alternatively one element is mounted for rotational movement relative to the other element. Such elements may define an axially located

aperture, the aperture initially receiving part of the gas generator. Alternatively the valve member may comprise an iris.

In one embodiment the said means to generate the signal after the bag is at least partially inflated comprise means to generate a signal a pre-determined time after the gas generator has been activated by the crash sensor.

Alternatively the said means to generate a signal are activated in response to a pre-determined pressure or a pre-determined rise in pressure within the air-bag.

Alternatively the means to generate the signal comprise a controller which is associated with one or more sensors, the sensors being adapted to determine one or more parameters relating to the vehicle.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a block diagram of one embodiment of the invention;

FIGURE 2 is a sectional view of part of a valve arrangement comprising one embodiment of the invention;

FIGURE 3 is a plan view of the arrangement of Figure 2;

FIGURE 4 is a sectional view of an alternative valve arrangement;

FIGURE 5 is a plan view of part of the arrangement as shown in Figure 4;

FIGURE 6 is a sectional view of a further type of valve arrangement prior to actuation;

FIGURE 7 is a sectional view corresponding to Figure 6 illustrating the valve after actuation;

FIGURE 8 is a sectional view of part of a gas generator and valve arrangement;

FIGURE 9 is a plan view of the arrangement of Figure 8;

FIGURE 10 is a side elevational view of the arrangement of Figures 8 and 9;

FIGURE 11 is a side view illustrating a further embodiment of the invention;

FIGURE 12 is a plan view of the arrangement of Figure 11;

FIGURE 13 is a plan view of an arrangement similar to that of Figures 11 and 12;

FIGURE 14 is a block diagram illustrating embodiments of the invention;

FIGURE 15 is a block diagram illustrating modified embodiments of the invention;

FIGURE 16 is a block diagram illustrating a further modified embodiment of the invention; and

FIGURE 17 is a block diagram illustrating yet another embodiment of the invention.

Referring to the drawings, it is envisaged that in a safety arrangement for a motor vehicle comprising an embodiment of the invention an air-bag 1 will be provided adapted to be inflated by a gas generator 2, the gas generator 2 being activated by a crash sensor 3. The air-bag is provided with a valve 4. The valve 4 is adapted to be opened when the air-bag has been at least partially inflated to permit gas within the air-bag to be exhausted to the atmosphere. The valve is opened in response to a signal which, in Figure 1, is illustrated as being generated by a signal generator 5. As will be explained hereinafter, the signal generator 5 may take various forms.

Because the valve is opened in response to a signal, which is generated after the air-bag is at least partially inflated, the valve can be caused to open at a pre-determined instant, or at an instant which is appropriate to the circumstances experienced during any particular crash.

The valve will consequently not be a valve of the type which is broken when subjected to a pre-determined high pressure. Also the valve is not automatically opened when the air-bag becomes fully inflated, but is only opened in response to the appropriate signal.

Figures 2 and 3 illustrate one type of valve. An aperture 10 is formed in the air-bag 11, the aperture 10 initially being sealed by a disc 12 which may be formed of

a rubber or plastic material. The disc 12 is of a predetermined thickness but has an arcuate portion 13 of reduced thickness. A pyrotechnic charge 14 is provided located adjacent part 15 of the region 13 of reduced thickness. An electric lead 16 is associated with the pyrotechnic charge in order to trigger or ignite the charge. The charge is such that when ignited a flame from the charge will burn through the part 15 of the region 13. Once the part 15 has been burnt through, the material of the disc 12 will tear along the region of reduced thickness 13, thus defining a flap which can open to permit gas to be vented from the air-bag.

Figures 4 and 5 illustrate a further type of valve arrangement. In the arrangement of Figures 4 and 5 a laminated air-bag is provided, the laminate comprising a first layer 20 and a second layer 21. An aperture 22 is formed in the first layer 20, this aperture being spanned by a membrane 23 formed by the second layer 21.

A housing 24 connected to the air-bag contains a pyrotechnic charge 25 which is contained within a smaller housing 26 which defines a cylinder. A piston element 27 is mounted for sliding movement within the cylinder, the piston element 27 carrying a knife or cutting blade 28 which is of cruciform configuration, as can be seen from Figure 5.

On actuation of the valve the pyrotechnic charge 25 is ignited, thus driving the piston 27 away from the housing 26 which defines the cylinder. This brings the blade 28 into engagement with the membrane 23, cutting the membrane. Gas is thus permitted to escape from the inflated air-bag.

Figure 6 illustrates yet another valve arrangement. In the arrangement of Figure 6 an air-bag is formed of fabric 30 which defines an aperture 31. Initially a layer of a further fabric 32 spans across the aperture 31 and may be retained in position by frangible stitching. The further fabric 32 passes under a guide 33, and is then connected to the peripheral edge of a balloon 34. Initially the balloon 34 is not inflated. Part of the balloon 34 is secured, for example by stitching 35, to the fabric forming the air-bag 30. Contained within the balloon 34 is a pyrotechnic squib 36 which is associated with an electric lead 37.

The valve is actuated by triggering the squib 36. Gas generated by the squib 36 inflates the balloon 34. Because part of the balloon 34 is secured to the fabric 30 forming the air-bag by the stitching 35, as the balloon inflates, the portion of fabric 32 that initially sealed the aperture 31 is drawn away from the aperture, breaking the frangible stitching. The aperture 31 is thus opened to permit gas to escape from the air-bag.

Figure 8, 9 and 10 illustrate a further arrangement.

Referring to Figures 8 to 10, a support 40 is provided adapted to be secured to an aperture formed in an air-bag. The support 40 supports a gas generator 41 adapted to inflate the air-bag and a valve assembly 42 adapted to be opened in response to a signal generated after the bag has been at least partially inflated in order to permit gas from within the bag to be exhausted from the bag.

The gas generator 41 may be of a conventional design and need not be described here in detail.

The valve 42 is a valve of the hit-and-miss type. The valve comprises two co-operating plates, each of which defines a plurality of apertures. The plates may be moved from a position in which the apertures are mis-aligned, when the valve is in the closed condition, to a position in which the apertures are co-aligned, when the valve is in the open position.

The valve comprises a fixed plate 43, which defines a plurality of apertures 44. Opposed peripheral parts of the fixed plate 43 are folded upwardly and inwardly to form guide tabs 45. A linearly moveable plate 46 is slidably mounted between the guide tabs 45, the moveable plate defining apertures 47.

A piston-and-cylinder-type pyrotechnic device 48 is provided mounted on the plate 43 and engaging an abutment 49 provided on the moveable plate 46. On actuation of the pyrotechnic device 48 the moveable plate 46 moves from an initial position as shown in Figure 9 in which the apertures 44 are mis-aligned relative to the apertures 47, to a position in which the apertures 44 and 47 are co-aligned. The valve is thus moved to the open condition.

Figure 11 and 12 illustrate a similar arrangement to that illustrated in Figures 8 to 10 in that in the arrangement of Figures 11 and 12 a hit-and-miss-type arrangement is utilised. However, in Figures 11 and 12 the moveable element is moved not linearly, but in a rotary manner. The moveable element is mounted symmetrically relative to the gas generator.

Referring to Figures 11 and 12, a support 50 is provided, there being a gas generator 51 and a valve arrangement 52 mounted on the support 50. Sealingly connected to the support is an air-bag 53. The part of the air-bag 53 that is connected to the support is a lip that surrounds an aperture formed in the air-bag. A cover 54 is provided.

The gas generator 51 is of conventional design. A lower part 55 of the gas generator extends downwardly through an aperture formed in the support 50 and also through an aperture 56 formed in the centre of a rotatable hit-and-miss element 57. The rotatable element may be moved, by means of a pyrotechnic piston-and-cylinder device 58 from an initial position shown in solid line, in which apertures 59 present in the shutter element are mis-aligned relative to apertures 60 formed in the support plate 50, to a position shown in dotted line 59', in which the two sets of apertures are co-aligned.

Figure 13 illustrates a modified embodiment of the invention which is similar to that shown in Figures 11 and 12. However, in the arrangement of Figure 13 an "iris" arrangement is provided. In an initial condition the iris defines a central aperture which accommodates a protruding part of a gas generator, such as a part equivalent to part 55 of the Figure 11 arrangement. A pyrotechnic device is provided which can open the iris to permit gas to escape from the air-bag.

As can be seen in Figure 13, a support 70 is provided. A ring-shaped element 71 is secured to the support which traps a lip portion of an air-bag, which defines an aperture within the air-bag, to the support 70. A pyrotechnic piston-and-cylinder device 72 is provided

which is adapted to drive an iris mechanism 73. In the initial condition illustrated the iris mechanism defines a central aperture 74. The central aperture 74 is adapted to receive a depending part of a gas generator and is adapted to form a substantial sealing fit against the gas generator. When the pyrotechnic device is activated the iris opens, thus enlarging the diameter of the aperture 74. This defines an air passage for gas to escape from the air-bag.

As mentioned with reference to Figure 1, in embodiments of the invention, the valve 4 is opened in response to a signal which is generated or supplied to the valve after the air-bag is at least partially inflated.

As illustrated in Figure 14, the crash sensor 3 may provide a signal to the gas generator to activate the gas generator as soon as a crash is sensed. The crash sensor may also provide a signal to an appropriate delay device, such as the delay device 6, thus subsequently activating the signal generator. Consequently the valve may, in an embodiment such as illustrated in Figure 14, be opened a pre-determined time after activation of the gas generator 2.

Referring to Figure 15, the crash sensor 3 may be of the type which generates a shock which can be transferred, from the crash sensor by means of a so-called shock tube 80. Such tube may be sold under the Registered Trade Mark NONEL. The shock tube 80 may be connected to a first squib 81 which activates the gas generator 2. A further length of shock tube 82 may subsequently extend to a second squib 83 which activates the valve 4.

It is to be appreciated that in an alternative embodiment which is similar to that shown in Figure 15 a first relatively short length of shock tube may extend from the crash sensor to the first squib 81 and a second relatively long length of shock tube may extend from the crash sensor to the squib 83. The shock does take a pre-determined time to travel along the shock tube. Consequently because the shock received by the squib 83 has to travel a greater distance than the shock received by the squib 81, the squib 83 will be activated a pre-determined time after activation of the squib 81.

Figure 16 illustrates another modified embodiment of the invention. In this embodiment the crash sensor 3 closes an electric switch 90 which controls activation of the gas generator 2. A pressure sensor 91 is provided responsive to pressure within the air-bag. The pressure sensor 91 controls a second switch 92, which switch controls actuation of the valve 4. Consequently in this embodiment of the invention, the signal that is generated to activate the valve is activated in response to a pre-determined pressure sensed by the pressure sensor, or a pre-determined change in pressure sensed by the pressure sensor. In any event, the signal is generated after at least partial inflation of the air-bag.

Figure 17 illustrates a further embodiment of the invention which is similar to that shown in Figure 16. In the embodiment of Figure 17 the crash sensor 3 again activates a switch 90 to activate the gas generator 2. The switch 90, however, also activates a controller 93. The controller 93 is associated with various sensors 94. The sensors may provide data to the controller such as the speed of the vehicle before impact, the rate of deceleration of the vehicle, and/or information concerning

the position of an occupant of the vehicle relative to the seat. Consequently the sensor may provide information as to whether an occupant of the vehicle is leaning forwards in the seat or is sitting fully back in the seat. The controller 93 will process the information provided by the sensors 94, thus activating the second switch 92 at an appropriate instant to open the valve 4.

CLAIMS:

1. A safety arrangement for a motor vehicle comprising an air-bag, gas generator means adapted to inflate the air-bag, crash sensor means adapted to activate the gas generator to inflate the air-bag, a valve which is initially in the closed condition, but which can be opened to permit gas within the air-bag to be vented from the air-bag, the valve being opened in response to a signal, means being provided to generate the signal to open the valve after the bag is at least partially inflated.

2. An arrangement according to Claim 1, wherein the valve is actuated by pyrotechnic means.

3. An arrangement according to Claim 2, wherein the said pyrotechnic means are adapted to burn part of the valve element to cause the valve element to open.

4. An arrangement according to Claim 3, wherein the valve element comprises an element of material of pre-determined thickness having a region of lesser thickness, the pyrotechnic charge being adapted to burn part of the region of lesser thickness.

5. An arrangement according to Claim 2, wherein the valve comprises a knife or cutting blade adapted to cut part of the air-bag.

6. An arrangement according to Claim 5, wherein the said knife is mounted on a piston element which cooperates with a cylinder associated with the pyrotechnic charge, activation of the pyrotechnic charge being adapted to drive the knife from an initial position to a position in which the knife or cutting blade cuts the air-bag.

7. An arrangement according to Claim 2, wherein the pyrotechnic device is contained within an inflatable balloon, the inflatable balloon being connected to an element which initially seals an aperture formed in the air-bag, the arrangement being such that inflation of the balloon causes the said element to move to a position in which the aperture in the air-bag is no longer sealed.

8. An arrangement according to any one of the preceding Claims, wherein the valve comprises two elements, one element being moveable relative to the other element, each of the elements defining at least one aperture therein, the arrangement being such that the aperture or apertures are initially mis-aligned but, subsequent to the said movement, are co-aligned.

9. An arrangement according to Claim 8, wherein one element is slidable linearly relative to the other element.

10. An arrangement according to Claim 8, wherein one element is mounted for rotational movement relative to the other element.

11. An arrangement according to Claim 9, wherein the said elements define an axially located aperture, the aperture initially receiving part of the gas generator.

12. An arrangement according to any one of Claims 1 to 7, wherein the valve member comprises an iris.

13. An arrangement according to any one of the preceding Claims, wherein the said means to generate the signal after the bag is at least partially inflated comprise means to generate a signal a pre-determined time

after the gas generator has been activated by the crash sensor.

14. An arrangement according to any one of Claims 1 to 12, wherein the said means to generate a signal are activated in response to a pre-determined pressure or a pre-determined rise in pressure within the air-bag.

15. An arrangement according to any one of Claims 1 to 12, wherein the means to generate the signal comprise a controller which is associated with one or more sensors, the sensors being adapted to determine one or more parameters relating to the vehicle.

16. A safety arrangement substantially as herein described with reference to and as shown in Figure 1 of the accompanying drawings.

17. A safety arrangement substantially as herein described with reference to and as shown in Figures 2 and 3 of the accompanying drawings.

18. A safety arrangement substantially as herein described with reference to and as shown in Figures 4 and 5 of the accompanying drawings.

19. A safety arrangement substantially as herein described with reference to and as shown in Figures 6 and 7 of the accompanying drawings.

20. A safety arrangement substantially as herein described with reference to and as shown in Figures 8 to 10 of the accompanying drawings.

21. A safety arrangement substantially as herein described with reference to and as shown in Figures 11 and 12 of the accompanying drawings.

22. A safety arrangement substantially as herein described with reference to and as shown in Figure 13 of the accompanying drawings.

23. A safety arrangement substantially as herein described with reference to and as shown in Figure 14 of the accompanying drawings.

24. A safety arrangement substantially as herein described with reference to and as shown in Figure 15 of the accompanying drawings.

25. A safety arrangement substantially as herein described with reference to and as shown in Figure 16 of the accompanying drawings.

26. A safety arrangement substantially as herein described with reference to and as shown in Figure 17 of the accompanying drawings.

27. Any novel feature or combination of features disclosed herein.

Amendments to the claims have been filed as follows

1. A safety arrangement for a motor vehicle comprising an air-bag, gas generator means adapted to inflate the air-bag, crash sensor means adapted to activate the gas generator to inflate the air-bag, a valve which is initially in the closed condition, but which can be opened to permit gas within the air-bag to be vented from the air-bag, the valve being opened in response to a signal, means being provided to generate the signal to open the valve after the bag is at least partially inflated, wherein the valve comprises two elements, one element being moveable relative to the other element, each of the elements defining at least one aperture therein, the arrangement being such that the aperture or apertures of the elements are initially mis-aligned but, subsequent to the said movement, are co-aligned.

2. An arrangement according to Claim 1, wherein the valve is actuated by pyrotechnic means.

3. An arrangement according to Claim 1 or 2, wherein one element is slidable linearly relative to the other element.

4. An arrangement according to Claim 1 or 2, wherein one element is mounted for rotational movement relative to the other element.

5. An arrangement according to Claim 4, wherein the said elements define an axially located aperture, the aperture initially receiving part of the gas generator.

6. An arrangement according to any one of the preceding Claims, wherein the said means to generate the

signal after the bag is at least partially inflated comprise means to generate a signal a pre-determined time after the gas generator has been activated by the crash sensor.

7. An arrangement according to any one of Claims 1 to 5, wherein the said means to generate a signal are activated in response to a pre-determined pressure or a pre-determined rise in pressure within the air-bag.

8. An arrangement according to any one of Claims 1 to 5, wherein the means to generate the signal comprise a controller which is associated with one or more sensors, the sensors being adapted to determine one or more parameters relating to the vehicle.

9. A safety arrangement substantially as herein described with reference to and as shown in Figure 1 of the accompanying drawings.

10. A safety arrangement substantially as herein described with reference to and as shown in Figures 2 to 4 of the accompanying drawings.

11. A safety arrangement substantially as herein described with reference to and as shown in Figures 5 and 6 of the accompanying drawings.

12. A safety arrangement substantially as herein described with reference to and as shown in Figure 7 of the accompanying drawings.

13. A safety arrangement substantially as herein described with reference to and as shown in Figure 8 of the accompanying drawings.

14. A safety arrangement substantially as herein described with reference to and as shown in Figure 9 of the accompanying drawings.

15. A safety arrangement substantially as herein described with reference to and as shown in Figure 10 of the accompanying drawings.